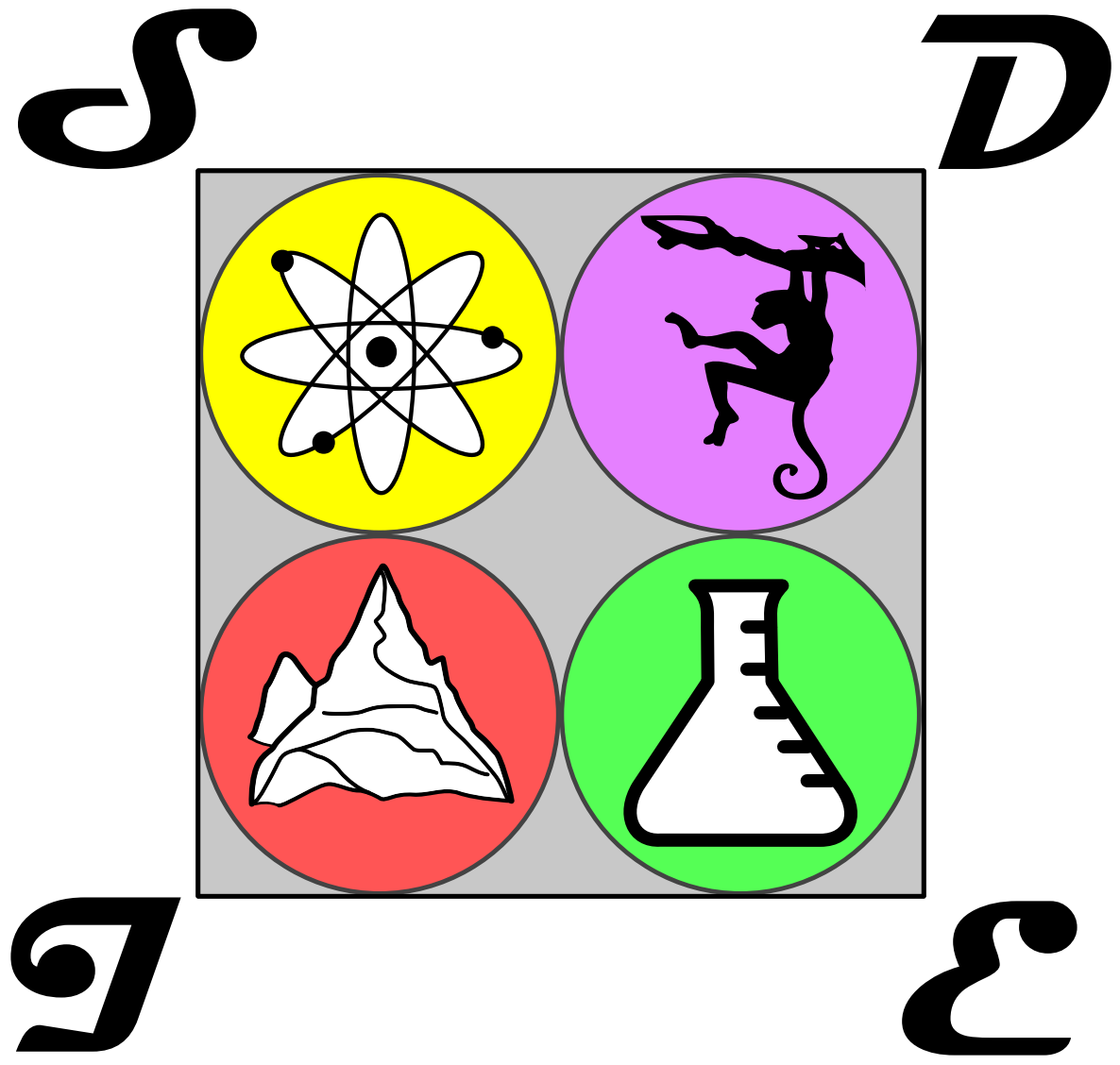
Science Done in English



Douglas Perkins

February 14, 2021

Preface

"*The imagination of nature is far, far greater than the imagination of man.*"

– Richard Feynman, "The Value of Science" (1955)

"*Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.*"

– Marie Curie (1867–1934)

"*It is a wholesome and necessary thing for us to turn again to the earth and in the contemplation of her beauties to know the sense of wonder and humility..*"

– Rachel Carson, "The Sense of Wonder" (1956)

A geologist examining rocks in California.

A good way to learn to do science in English is to do science in English. When students are doing things, they are engaged, and that is when learning occurs. This book has three parts: biology, physics, and earth science. I have tried to select topics that don't require any specific background knowledge. The pieces are independent. Take whatever looks best for you and forget about the rest.

I wrote this book for a tenth grade English class in Japan. My students are planning to study abroad. Many of them will attend classes in English that make use of technical terms they've never seen. This book, and the accompanying course, are part of an attempt to ease this transition. The first edition was finished in the summer of 2015.

– Douglas Paul Perkins. Nishitokyo, Japan.

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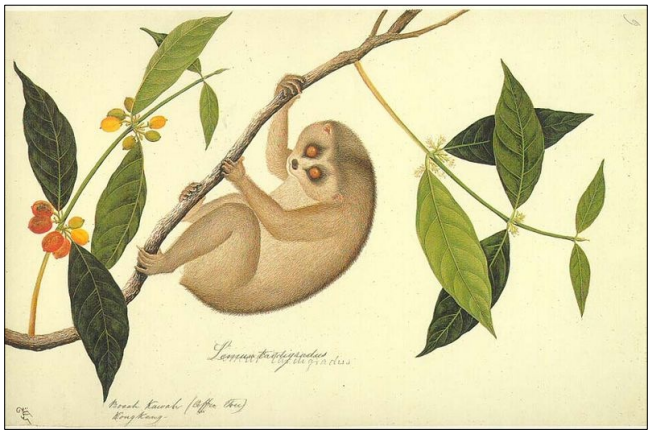
Northbound on the Alaska Highway.

Part I: Biology

Gulls. By Daniel Gammert.



A lemur in a coffee tree. 1819–1823.

Chapter 1: Life

Key Words

Match the word and hint.

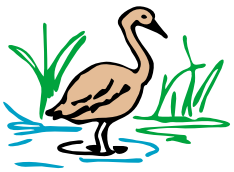
1.	____ herbivores	A.	Animals with a backbone.
2.	____ carnivores	B.	Animals without a backbone.
3.	____ reptiles	C.	Animals that usually eat meat.
4.	____ omnivores	D.	Animals that usually eat plants.
5.	____ cold-blooded	E.	Animals with hair and mammary glands.
6.	____ vertebrates	F.	Animals that usually eat plants and meat.
7.	____ invertebrates	G.	Warm-blooded egg laying feathered animals.
8.	____ birds	H.	Animals with little control of body temperature.
9.	____ mammals	I.	Animals that live first in water and then on land.
10.	____ amphibians	J.	Cold-blooded scaly skinned animals that lay eggs.

Brainstorm Plants and Animals

Name some organisms.

A. Fish.
B. Trees.
C. Insects.
D. Flowers.
E. Small animals.
F. Large animals.

G. Mammals.
H. Amphibians.
I. Large carnivores.
J. Small herbivores.
K. Carnivorous birds.
L. Cold-blooded vertebrates.



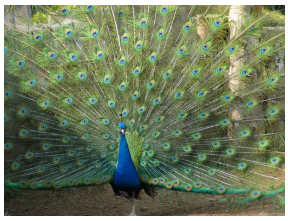
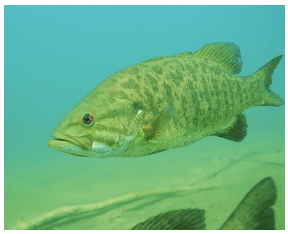
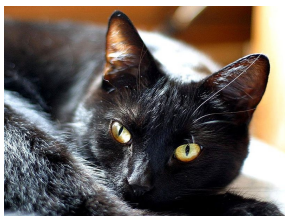
Minimal Pair Listening

Circle the word you hear.

1.	ant / and		6.	life / live	
2.	dog / dock		7.	cells / shells	
3.	tiger / tired		8.	plants / prance	
4.	owl / howl		9.	extinct / extent	
5.	mouse / moose		10.	biology / biography	

Classification

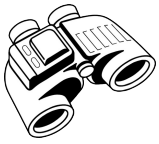
Identify the animal type.

1.		mammal bird reptile amphibian fish	5.		mammal bird reptile amphibian fish
2.		mammal bird reptile amphibian fish	6.		mammal bird reptile amphibian fish
3.		mammal bird reptile amphibian fish	7.		mammal bird reptile amphibian fish
4.		mammal bird reptile amphibian fish	8.		mammal bird reptile amphibian fish

True or False

Circle the answer.

1. Humans are mammals. TRUE / FALSE
2. Bears are cold-blooded. TRUE / FALSE
3. Monkeys are vertebrates. TRUE / FALSE
4. Bees can fly. TRUE / FALSE
5. Crows are warm-blooded. TRUE / FALSE
6. Mice are reptiles. TRUE / FALSE
7. Lions have two legs. TRUE / FALSE
8. Crocodiles are cold-blooded. TRUE / FALSE
9. Squid are invertebrates. TRUE / FALSE
10. Fish are mammals. TRUE / FALSE



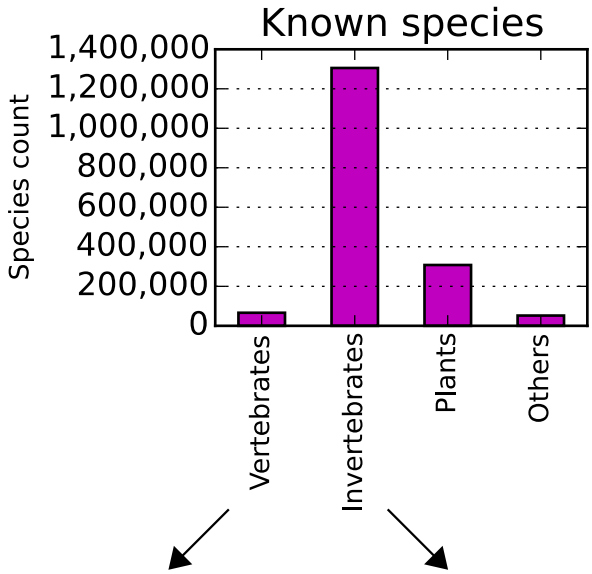
Background

What kinds of life do you know much about? It is easy for people to think of large cute animals. Off the top of your head, how many can you name? When we look at what kinds of life exist on Earth, though, there are far more small critters like ants, beetles, and bugs than there are cats, dogs, and orangutans.

mammals

birds

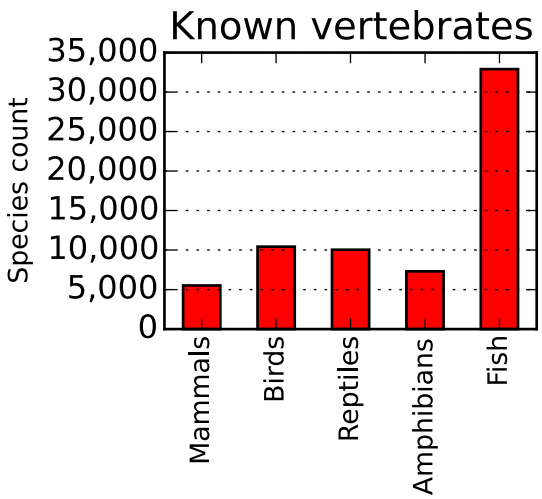
fish

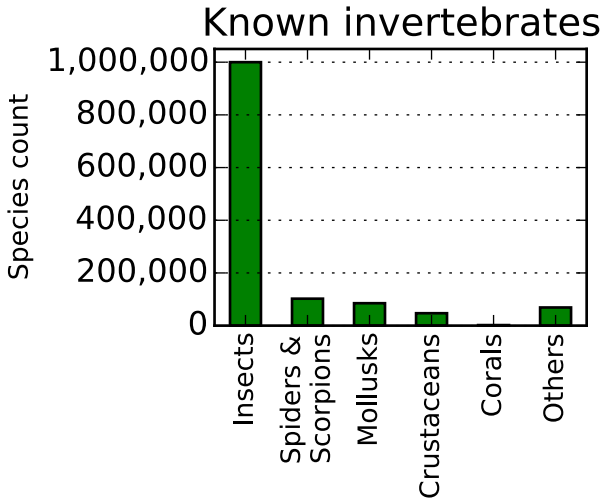


insects

spiders

mollusks





Questions

1. Are there more species of animals or plants? _____
2. Are there more species of mammals or fish? _____
3. Are there more species of insects or mollusks? _____
4. Are there more species of birds or insects? _____

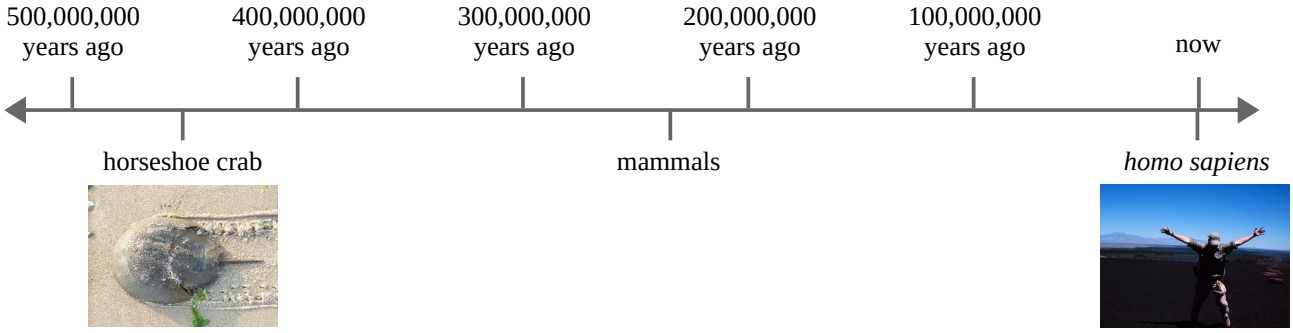
Hints About Animals

Guess the animals.

1. *This is a mammal. It has four legs. It is omnivorous. It likes to eat mice.*
2. *This is a large and dangerous reptile. It is carnivorous. It often hunts in the water.*
3. *This is an Australian mammal. It usually doesn't drink water. It eats Eucalyptus leaves.*
4. *This is the largest mammal in the world. It lives in the ocean and eats small fish.*
5. *This is the largest bird in the world. It cannot fly, but it runs very fast.*

Make your own hints, and ask your classmates to guess the animal.

The Oldest Animals

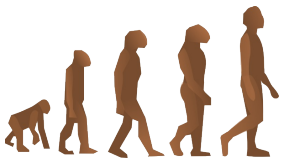


Which kinds of animals do you think are older?

				Guess	Answer
1.	humans	or	horseshoe crabs	_____	_____
2.	monkeys	or	cicadas	_____	_____
3.	mosquitoes	or	zebras	_____	_____
4.	cows	or	octopuses	_____	_____
5.	dragonflies	or	Tyrannosauruses	_____	_____

Biodiversity

Variety of life is important to our well-being. Food is a biological resource. New medicines sometimes come from rare species. Economic strength is in large part based on biological resources. Biodiversity gives us ecological goods like clean water and fresh oxygen. It also makes the world's ecosystem stable. The more species there are, the more stable the ecosystem. Life needs life to survive.



Chapter 2: Animals

1. alligator
2. ant
3. badger
4. bear
5. cat
6. cow
7. dog
8. dragonfly
9. elephant
10. elk
11. fish
12. flamingo
13. gibbon
14. gorilla
15. hedgehog
16. horse
17. ibex
18. iguana
19. jackrabbit
20. jaguar
21. kangaroo
22. koala
23. leopard
24. lion

25. moose
26. mouse
27. newt
28. nightingale
29. octopus
30. owl
31. pig
32. polar bear
33. quail
34. quoll
35. rabbit
36. raccoon
37. snake
38. squirrel
39. tiger
40. turtle
41. uakari
42. vulture
43. wallaby
44. wolf
45. xiphias
46. yak
47. Yorkshire terrier
48. zebra

Part II: Physics

A roller coaster in Ohio. 1930–1945.

Chapter 3: Gravity

Minimal Pair Listening

Circle the word you hear.

1.	fast	first	6.	fall	hall
2.	slow	throw	7.	thing	sing
3.	motion	ocean	8.	speed	speech
4.	physics	physical	9.	change	chains
5.	accelerate	acceleration	10.	velocity	velociraptor

Significant Figures

We can measure things, but instruments have limited precision. A measurement has a number of significant figures. When we calculate using those numbers, we should respect this limit.

Example	What's the average of 175 cm, 180 cm, and 183 cm?	179 cm	*Good*
Example	What's 2.22 seconds plus 1.11 seconds?	3.33 seconds	*Good*
Example	How much is 2.5 m plus 2.06 m?	4.56 m	*Bad*
Example	Find the average of 3.1 seconds and 3.8 seconds.	3.45 seconds	*Bad*
1.	How much is 8 years plus 10.4 years?	_____	
2.	How much is 10.11 minutes plus 1.003 minutes?	_____	
3.	What's the average of 5.00 m and 6.00 m?	_____	
4.	Calculate the average of 50.0 kg, 51.0 kg, and 54.0 kg.	_____	
5.	What's the average of 90 years, 90 years, and 91 years?	_____	

Experiment Time

Stand on a chair, drop things, and see how long it takes for them to land.

	Object	Time 1	Time 2	Time 3	Average
1.	a sheet of paper				
2.	a ball of paper				
3.	an empty plastic bottle				
4.	a super ball				
5.	a penny				

Calculating distance (in meters) from time (in seconds)...

on Earth: $d = \frac{1}{2} \times 9.81 \times t^2$

on the Moon: $d = \frac{1}{2} \times 1.63 \times t^2$

Questions

Assume there is room for the coin to fall and ignore air resistance.

Let's consider the Eiffel Tower…

1. If you drop a coin, how far will it fall in 1.0 seconds? _____
2. If you drop a coin, how far will it fall in 2.0 seconds? _____
3. How long will it take for the coin to hit the ground? _____

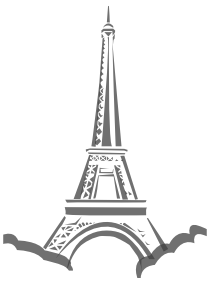
Let's consider the Tower of Pisa…

4. If you drop a coin, how far will it fall in 1.0 seconds? _____
5. If you drop a coin, how far will it fall in 3.0 seconds? _____
6. How long will it take for the coin to hit the ground? _____

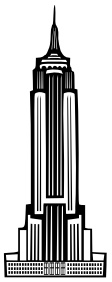
Imagine the Empire State Building is on the Moon…

7. If you drop a coin, how far will it fall in 3.0 seconds? _____
8. How long will it take for the coin to hit the ground? _____

Tower of Pisa
55.7 m



Eiffel Tower
300.7 m



Empire State Building
443.2 m

Gravity

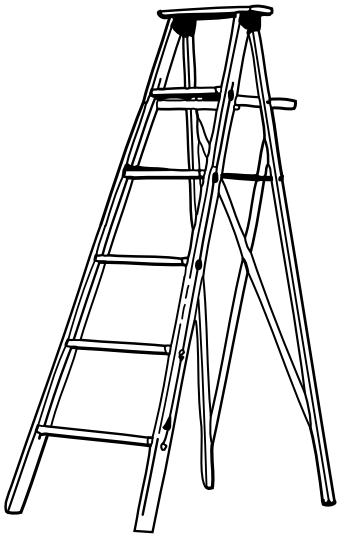
Weight is different from mass. We normally say things fall because the Earth's gravity pulls on them. We talk as if our weight is a given. Actually, weight changes when the pull of gravity changes. The Moon is much smaller, and the pull of gravity on the Moon is about one sixth that of Earth. So any object on the Moon weighs one sixth what it does on Earth. What does not change is the amount of matter in an object. That is called its mass. If you go to the moon, your mass will stay the same, but you will weigh much less.

– *Adapted from Gravity on Simple English Wikipedia*

Chapter 4: Egg Drop

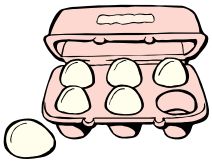
Project

Drop an egg from two meters so it won't break. You need something that can absorb the energy. If the egg lands too quickly, it will break. Try using everyday household items and arrange them so that the container absorbs the energy, keeping your egg safe and sound.



Possible Materials

- Tape
- Paper
- Tissues
- Paper towels
- Cardboard paper
- A plastic bottle (1L, 1.5L, or 2L)
- Straws
- Chopsticks
- Anything the teacher says is OK



Success

Build your container. Put the raw egg in it and drop it. Eggs that smash or crack fail, and eggs that survive without scratches pass.

Design

- Style 1: Parachute
- Style 2: Padded box
- Style 3: Paper and tape
- Style 4: Chopsticks or straws and rubber bands
- Boxes should be no larger than a 2L bottle

Considerations

1. Put the egg in a thin plastic bag. If it breaks, cleanup is easy.
2. When something falls fast, there is a lot of energy. Design a container to absorb it.
3. Your container might turn when it falls. Use a parachute or some ribbon to help.
4. Closed parachutes are useless. Connect parachutes to containers in at least two places.

Sample Report

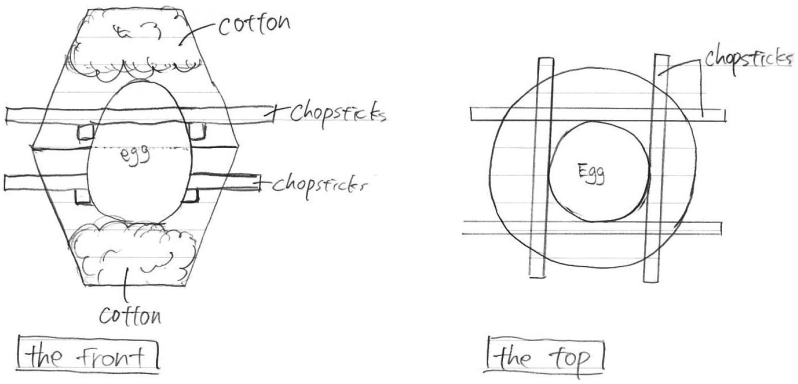
Read the sample egg drop report below. Then, write your own. Reports need: a proper title, the authors's names, the date, a list of materials, the total cost, a drawing of the design, an explanation of the design's strong points, and a summary of how the egg drop went. Other interesting information may also be included.

Egg Drop Report

Chris Knight & John Connor

October 21

Materials. For our container, we used these materials: a raw egg, two paper cups, some cotton balls, four chopsticks, and some scotch tape. We had the cups, chopsticks, and tape at our house, and the only thing we bought was a bag of cotton balls. The total cost was 108 yen.



Design. We chose a cup design because it's easy to build. When the bottom of the cup hits the ground, it will break and absorb a lot of energy. The cotton balls protect the egg. The chopsticks help strengthen the side of the container. This is important because the sides of the cup are not very wide.

Results. On October 21st, we put a raw egg in our container and dropped it from the second floor balcony at our school. Sadly, the egg broke. We wanted the container to land on the bottom cup, but it landed right on the chopsticks. The side of the cup is not very wide, and the egg had no chance. If the bottom cup had hit the ground first, we think it would have survived.

Part III: Earth Science

Volcanoes National Park, Hawaii.

Chapter 5: Volcanoes

Minimal Pair Listening

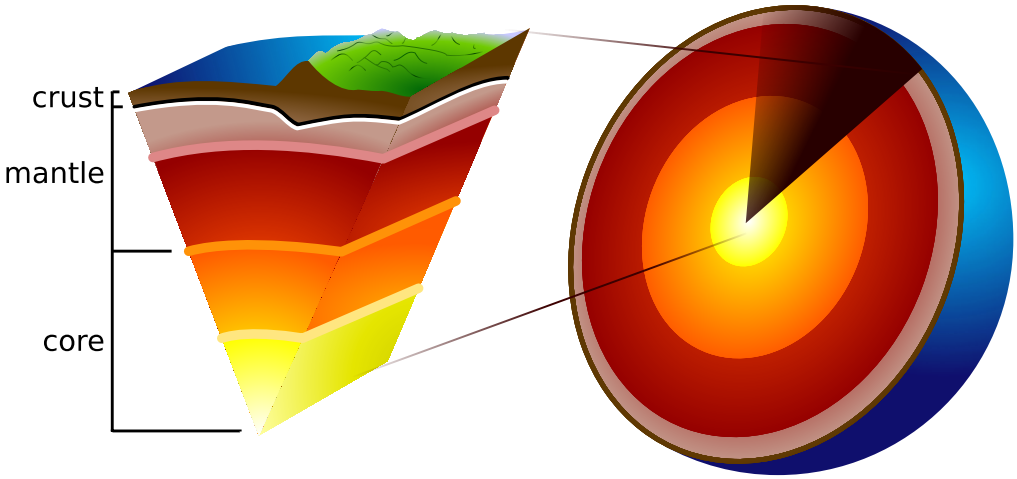
Circle the word you hear.

1.	heat	/ hit	6.	date	/ data
2.	rock	/ lock	7.	theory	/ teary
3.	same	/ seem	8.	problem	/ program
4.	science	/ signs	9.	geology	/ geologist
5.	crust	/ crushed	10.	universe	/ universal

Key Words

Match the word and hint.

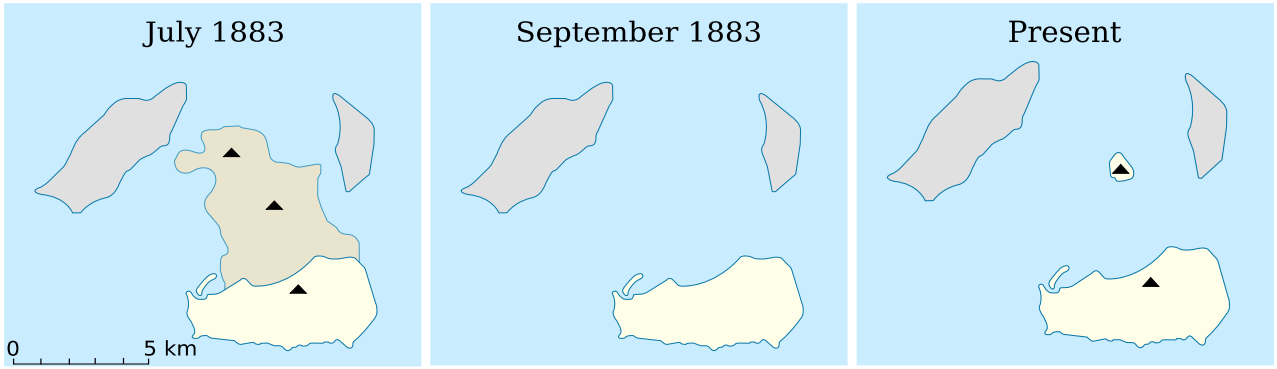
1.	____ volcano	A.	The center of the earth.
2.	____ magma	B.	The outer layer of the earth.
3.	____ lava	C.	The middle layer of the earth.
4.	____ mantle	D.	A dangerous mountain that can erupt.
5.	____ active volcano	E.	Hot liquid rock under the earth's surface.
6.	____ dormant volcano	F.	An old volcano that will never again erupt.
7.	____ extinct volcano	G.	The time when lava comes out of a volcano.
8.	____ core	H.	A volcano that has been quiet for a long time.
9.	____ eruption	I.	Hot liquid rock that came from a volcanic eruption.
10.	____ crust	J.	A volcano that has erupted in the last 10,000 years.



Krakatoa

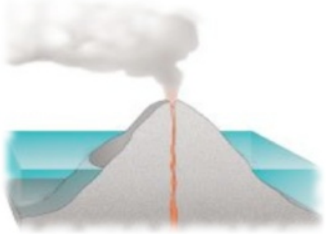
Krakatoa is an active volcano in the Sunda Strait of Indonesia. The volcano has erupted repeatedly in known history. The best known of these events occurred on August 26, 1883. This eruption ejected more than 25 cubic kilometers of rock and ash, and made the loudest sound ever recorded by human beings. The sound was heard as far away as Perth, Australia. Around 36,000 people were killed and injured by the eruption, including the tsunami that followed the explosion. The eruption destroyed two-thirds of the island. New eruptions since 1927 have built a new island, called Anak Krakatau (child of Krakatoa).

– Adapted from Krakatoa on Simple English Wikipedia



Volcano Presentation

Prepare and deliver a short presentation on a famous volcano or eruption. Some famous eruptions include Mount Vesuvius (A.D. 79), Krakatoa (1883), Mount St. Helens (1980), Mount Pinatubo (1991), Eyjafjallajokull (2010), and Mount Pelée (2010). Some famous volcanoes include Mauna Loa (Hawaii), Kīlauea (Hawaii) and Sakurajima (Japan).



Chapter 6: Space

Questions

1. What is the largest planet?

   _____

2. What is the smallest planet?

   _____

3. Which planet is closest to the Sun?

   _____

4. Which planet is farthest from the Sun?

   _____

5. Which planet has large rings?

   _____

6. Which listed thing isn't a planet?

   _____

7. What is called the “Red Planet”?

   _____

8. Which four planets are mostly made of gas?

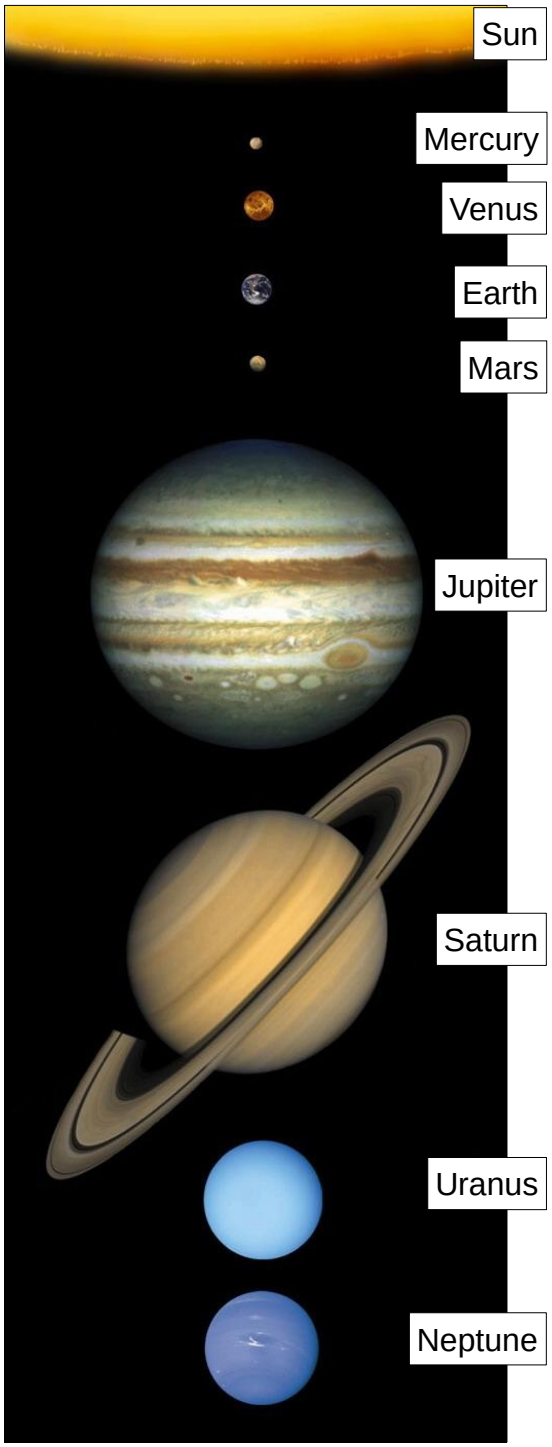
   _____

Thought Questions

9. If you wanted to live on another planet, where would you go?

10. What problems would you need to solve in order to do so?

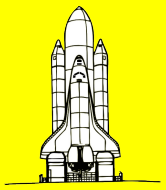
The Solar System



Planets to scale. Distances not to scale.

Distance

Use the data in the table and answers the questions.

Sun → Mercury	58 million km		Sun → Jupiter	777 million km
Sun → Venus	108 million km		Sun → Saturn	1.42 billion km
Sun → Earth	150 million km		Sun → Uranus	2.86 billion km
Sun → Mars	225 million km		Sun → Neptune	4.49 billion km

The above are average distances from planets to the sun.

1. Imagine we could drive a car to Venus at a cruising speed of 100 km/h. How many years would it take to reach the planet? _____
2. The fastest airplane ever built was the SR-71 "Blackbird". It could fly 3,530 km/h. Suppose we could fly the plane to Saturn. How many years would it take to reach the planet? _____
3. The speed of light, c, is around 3×10^8 m/s. About how many hours does it take for light from the Sun to reach Neptune? _____

Jupiter's Moons

Jupiter has 67 known moons. The four largest were seen by Galileo in the 1600s. The rest were later identified by spacecraft. The smallest moon is only one kilometer across. The largest moon, Ganymede, is bigger than the planet Mercury. The other three large moons are Io, Europa and Callisto. Because of gravity from Jupiter and other moons, Io is the most volcanic object in the Solar System. It has over 400 volcanoes.

– Adapted from Jupiter on Simple English Wikipedia

True or False

Circle the answer.

1. The largest moon is Europa. TRUE / FALSE
2. Galileo is the name of a moon. TRUE / FALSE
3. Ganymede is a planet. TRUE / FALSE
4. Io has many volcanoes. TRUE / FALSE
5. Jupiter has more moons than Earth. TRUE / FALSE

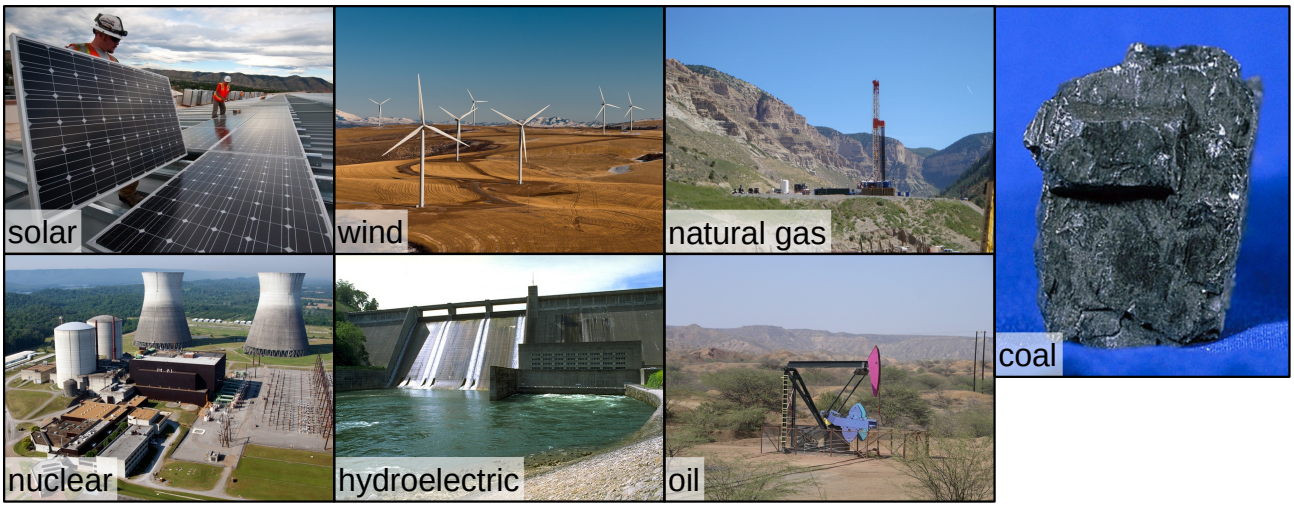
Io and Jupiter.

Chapter 7: Energy

Minimal Pair Listening

Circle the word you hear.

1.	coal	/ cold	6.	taste	/ takes
2.	gas	/ guess	7.	atom	/ add-on
3.	solar	/ seller	8.	source	/ sauce
4.	power	/ polar	9.	sample	/ sandal
5.	windy	/ Wendy	10.	electric	/ electrical



Thinking About Energy

1. Which of the energy sources shown above are renewable?

   _____

2. What are some dangers of nuclear energy?

   _____

3. What are some dangers of coal energy?

   _____

4. Under what conditions can you not use solar, wind, and hydroelectric energy?

   _____

   _____

a wind turbine

a wind farm

a nuclear power plant

Dangers of Power Sources

When reflecting on the Fukushima Daiichi disaster, we should remember that all sources of electricity involve risk, but wind and solar are among the safest. On March 11, 2011, a massive tsunami hit Japan's Hasaki Wind Farm in Kamisu, Ibaraki, but the seven wind turbines stood strong. At the Fukushima-Daiichi nuclear power plant, workers desperately tried to prevent a the situation from getting worse. Although that power plant was built with many safety systems and sturdy cement and steel, in the end those safety systems failed. Yet the wind farm, also struck by the tsunami, was just fine. Engineers say it simply did what it was built to do. "If you think about it … it's hard to get much better than a wind turbine for a source of energy production that will survive [a tsunami]," said Mark Rodgers, a wind energy industry veteran. He explained that the steel tower lets water slide around it without much damage. In fact, none of Japan's wind turbines broke down from the 2011 earthquake, according to the Japan Wind Power Association.

– *Adapted from The Dangers of Energy Generation by Elisa Wood (2011)*

Hasaki Wind Farm

Fukushima Daiichi Power Plant

True or False

Circle the answer.

1. Every source of electricity has some possible danger. TRUE / FALSE
2. Wind energy is relatively safe. TRUE / FALSE
3. Nuclear power plants are built with few safety features. TRUE / FALSE
4. Some wind turbines in Japan were damaged by the 2011 earthquake. TRUE / FALSE

1 W = 1 watt	1,000 W = 1 kW = 1 kilowatt
1 watt for 1 hour = 1 Wh = 1 watt-hour	1 kilowatt for 1 hour = 1 kWh = 1 kilowatt-hour
Price of electricity in Japan in 2017: Around ¥22 / kWh	

Household Electricity Use

toaster 850 W	microwave 1000 W	large refrigerator 1400 Wh/day	vacuum 1000 W
			
LCD TV 150 W	laptop 75 W	clock radio 7 W	ceiling fan 120 W
			

These numbers are estimates. Actual power consumption varies by device.

Use the above table. True or false.

1. A vacuum uses 1000 W of electricity. TRUE / FALSE
2. A ceiling fan uses 200 W of electricity. TRUE / FALSE
3. Microwaves use less electricity than toasters. TRUE / FALSE
4. LCD TVs use more electricity than laptop computers. TRUE / FALSE
5. Many kitchen appliances use a lot of electricity. TRUE / FALSE

Use the above table and answer the questions.

6. How many watt-hours of electricity does a laptop use in 2 hours? _____
7. How many watt-hours of electricity does a clock radio use in a day? _____
8. How many watt-hours of electricity does a microwave use in 15 minutes? _____
9. How many watt-hours of electricity does a ceiling fan use in 5 hours? _____
10. How many watt-hours of electricity does a large refrigerator use in a day? _____

BULB			
TYPE	incandescent	CF	LED
WATTS	60W	14W	10W
NEW BULB COST	$1	$2	$8
BULB LIFESPAN	1,200 hours	8,000 hours	25,000 hours
LIGHT PRODUCED	*These three bulbs produce the same amount of light.*		

Compare Light Bulb Efficiency

1. How many kilowatts (kW) does each bulb type use?

   Incandescent: $60 / 1000 = 0.06$ kW

   CF: _____

   LED: _____

2. In 2015, U.S. electricity cost about $0.12 per kWh. What is the electricity cost for one hour?

   Incandescent: $0.06 \times 0.12 = \$0.0072$

   CF: _____

   LED: _____

3. What is the total cost (bulbs + electricity) for each type if used for 8,000 hours?

   Incandescent: $(7 \times 1) + (0.0072 \times 8000) = \$64.60$

   CF: _____

   LED: _____

4. What is the total cost (bulbs + electricity) for each bulb type if used for 24,000 hours?

   Incandescent: $(20 \times 1) + (0.0072 \times 24000) = \$192.80$

   CF: _____

   LED: _____

5. Suppose you use incandescent lights at your home now. When should you replace them?

   _____

Chapter 8: Lifestyle

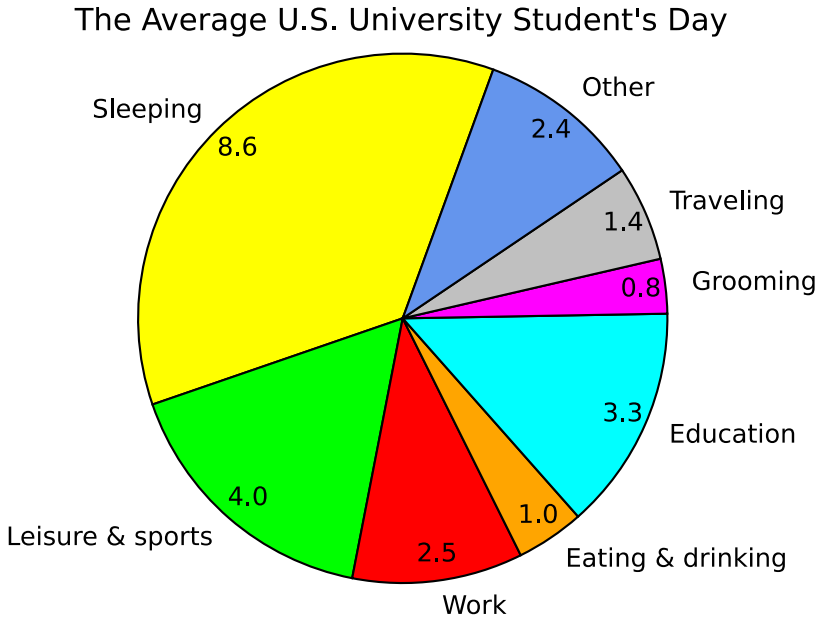
Choices

How can these choices impact the environment?

1. A student gets a ride to school instead of walking or bicycling.
2. A student watches TV after school instead of playing in the park.
3. Instead of bringing a backpack, a student gets a new plastic bag at the store.
4. A present is put in a box, wrapped, put in a paper bag, and then in a plastic bag.
5. A man in Tokyo buys a box of cherries from the grocery store in April.

Conservation

There is a saying: “Reduce, reuse, recycle.” To reduce means to use less. To reuse means to use things again or in different ways. Recycling is a process where things are transformed into a new form so they can be used again. How do you do these things now? Can you do these things more?



Time

- What in the data surprises you?
- Do you think this shows a balanced lifestyle?
- Do you spend the same amount of time doing these things?

Blind Taste Test

Drink and compare five kinds of water.

SAMPLE	COLOR	SMELL	TASTE	AFTERTASTE	OTHER
Example notes	*clear cloudy*	*metallic chemical smell none*	*salty sweet*	*bitter none*	
A					
B					
C					
D					
E					

Ranking

Which sample did you like the best?

BEST		OK		WORST

Sources

Find out where the water came from.

SAMPLE	BRAND	PLACE OF ORIGIN
A		
B		
C		
D		
E		

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